# Selection and Evaluation of Travel Demand Management Measures

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Travel demand management (TDM) measures are designed to alter the attractiveness of competing travel modes to prompt individuals to carpool or use transit instead of driving alone. Determining the best set of measures for a given area and estimating the effectiveness of the selected measures involve understanding the characteristics of the available transportation modes and of the area's travelers. The process of developing the best, comprehensive set of TDM measures for the Syracuse, New York, area and predicting the effect of those measures are described. Based on a case study of the best TDM measures and their effect in Syracuse, a procedure is presented that can be used for similar studies elsewhere. An effort is made to use data that would be available for similar studies. The evaluation tool is one that would be available in any other area. The main source of information about the travel patterns was census journey-to-work information. Additional information about employment, transit service, roadway congestion, and so forth was derived from planning reports developed by the local metropolitan planning organization. Similar reports should be available in other areas because of the strict planning provisions of the Intermodal Surface Transportation Efficiency Act of 1991. The major conclusion was that it is indeed possible to select an appropriate set of TDM measures for a given study area while relying on only limited, readily available data and tools.

Traffic congestion and delay have reached levels that threaten the well-being of both urban area travelers and urban economies. Although this problem threatens to increase in magnitude over time, the options available to address the problem have become more limited. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) (*1*), sensitive to environmental concerns and fiscal restraints, has severely limited expansion of highways to solve the apparent disparity between urban transportation system supply and travel demand. Hence, new methods to bring supply into line with demand have become the center of attention.

Modern efforts can be split into two categories: transportation system management (TSM) and travel demand management (TDM). TSM measures are designed to increase system efficiency through operational improvements, thereby increasing the demand that can be accommodated. TDM measures, on the other hand, are designed to entice travelers to use higher occupancy modes, thereby reducing the number of vehicle trips that must be carried by the system.

Although estimating the increased throughput possible after improved signalization at an intersection is straightforward, choosing a program of TDM measures to bring about the desired level of trip reduction is rather difficult. TDM measures are designed to alter the attractiveness of competing travel modes to prompt individuals to carpool or use transit instead of driving alone. Determining the best set of measures for a given area and estimating the effectiveness of the selected measures can be quite difficult. The process involves understanding the characteristics of the available transportation modes and of the area's travelers.

The objectives of this paper were to develop a systematic process of identifying the best, comprehensive set of TDM measures for the Syracuse, New York, area and predicting the effect of those measures. Although the research is based on a specific case study, which was necessary to identify and use generally available data, the goal was to develop a procedure that could be applied in other metropolitan areas. This objective required the use of readily available data as well as access to appropriate evaluation tools.

## BACKGROUND AND TDM CATEGORIZATION

There are many ways transportation planners, engineers, politicians, local citizens' interest groups, and employers can attempt to influence travel demand. Efforts can be made to decrease the need to travel or to influence by what mode or at what time people travel. Only broad categories of TDM measures are discussed in this section. This effort provides an overview of the theory behind most TDM actions. Insight is also provided about when particular strategies work best and why.

TDM measures can be categorized in a variety of ways depending on the researcher's point of view. Tanaboriboon (*2*) separates 66 different TDM strategies into six categories, namely, traffic constraints, public transportation improvements, peak-period dispersion, ride sharing, parking controls, and land-use control techniques. In addition to Tanaboriboon's own grouping of the numerous TDM strategies available, three other possible approaches, ranging from 4 to 11 categories, are outlined. Park (*3*) originally developed the definition of 66 different strategies and provided an exhaustive listing of cities worldwide where each had been implemented.

One of the more interesting categorizations was by Rosenbloom (*4*), who divided essentially 18 different techniques into four categories: social, socioeconomic, sociotechnical, and technical approaches. Still another approach was offered by Ferguson (*5*), who categorized TDMs according to the four steps of the urban transportation planning process—namely, trip generation, trip distribution, mode choice, and route selection. However categorized, TDM measures are essentially designed with one of three primary goals in mind—namely, increasing the use of alternative modes, discouraging the single-occupant vehicle (SOV) mode choice, and shifting travel demand to off-peak times or alternative routes.

For the purpose of this paper, the four categories of TDMs considered are travel constraints, stimulation of alternative mode usage, alternative work arrangements, and land-use planning.

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### Travel Constraints

The broad category of travel constraints includes strategies designed to either increase the generalized cost of travel or restrict usage of portions of the transportation network. Constraints can be aimed at a particular mode of travel, such as the SOV mode, by imposing restrictions on automobile use through physical, economic, or legal restraints. Traffic along a specific route also can be targeted by imposing roadway charges. May (*6*) advocates partitioning traffic restraining TDMs into the following four categories: physical restrictions, time penalties, regulatory controls, and pricing methods.

### Stimulation of Alternative Mode Usage

Efforts to increase the attractiveness, availability, and public awareness of high-occupancy vehicle (HOV) modes must be implemented along with disincentives to use automobiles. Methods include improvements to alternative modes, such as a better relationship between transit routing and scheduling and travel patterns, more pleasant transit service characteristics, construction of bicycle or walking paths, carpool and vanpool support programs, and preferential treatment of HOV modes along the roadways and at the destination. In addition, pricing incentives can be instituted to improve the competitive position of HOV modes. Finally, aggressive marketing of HOV options to increase public awareness of the many travel choices is crucial. Without such efforts to assist people deciding to switch to HOV modes, attempts to discourage SOV use will not be successful.

### Alternative Work Arrangements

Alternative work arrangements offer hope for relieving congestion in many metropolitan areas. Congestion often is caused more by concentration of demand for travel in time than in space. In most metropolitan areas, the roadway infrastructure is much more than adequate to handle average daily traffic. The excessive peak-period demands are undoubtedly caused by the similar workday schedules of most of the workforce. If these schedules can be altered, a reduced maximum demand achieved through dispersion of the peak period will relieve many congested areas. Some alternative work arrangements, such as telecommuting and shortened work weeks, spread out the peak period, although sometimes they can reduce the opportunity for carpooling and increase the likelihood of further residential dispersion. Furthermore, all the alternative work-arrangement strategies have been found to improve worker morale and productivity. It is obvious that these strategies are particularly attractive to the public sector, as they require only employer support and little or no infusion of public funding.

### Land-Use Planning

Proper land-use planning is an essential element of any long-term effort to reduce or slow the growth of vehicle miles traveled (VMT) in an urban area. Land-use planning can favorably alter the magnitude and location of travel demand placed on the network as well as beneficially influence modal split. Proper planning can promote the use of transit by controlling population density and development in areas currently or potentially effectively served by transit. Requiring developers to provide a bicyclist- and pedestrian-friendly environment is an important factor in promoting their use. Key elements of such efforts are sidewalks, adequate lighting, planting of shade trees, and mixed-use zoning requirements. Land-use control can relieve congestion in the urban core by encouraging large employers to locate away from city centers and close to residential areas. Finally, land-use planning can reduce the overall demand for travel through development of self-sufficient towns that offer employment, shopping, and other entertainment opportunities close to residences.

Unfortunately, land-use planning often faces difficulty because of public opposition, disregard for regulations, or rapidly changing situations. Expansive office parks with rolling lawns in suburban areas are attractive to business owners but essentially eliminate transit as a travel option for employees.

## OBJECTIVE OF A TDM EVALUATION APPROACH

Evaluation of TDMs turns out to be the critical aspect of implementing an appropriate and effective set of traffic reduction measures. The procedure should be able to demonstrate that the selected set of measures is the best and that it will have long-term benefits for the public that outweigh the inconvenience and cost associated with the selected measures. To support the decision, it is also necessary to show that something needs to be done—that to stay the course and maintain current travel behavior will only lead to worsening congestion, hamper economic growth, and cause further environmental decay.

For each suggested action, the cost of taking that action and the resulting benefits that will accrue to the public must be quantified. The procedure must be able to demonstrate that the selected set of measures will bring about the greatest long-term benefits for all at the least cost. It should be able to evaluate many different types of strategies that range from changes in cost or travel time for any mode to more difficult to measure mechanisms for those who wish to switch to alternative modes, such as guaranteed-ride-home programs or employer-based child-care programs.

To develop a procedure that is easily transferable among urban areas, it is important to use input that is readily available. This was an important aspect of this research. The characteristics of the area's travelers are required, because the goal is to estimate the resulting behavior of travelers. Certainly, existing modal split is required. Moreover, the current level of service of area roadways is needed to illustrate the need to take some action as well as to form a basis by which to judge the reduction in congestion that will result from the changes in behavior. Much of this information is readily available from census data, technical reports developed for any urban area, and existing planning models.

The output of such a model should be the resulting modal shares that can be expected and the reduction in vehicle miles of travel so that the benefits can be assessed. The costs involved with implementing the program also should be calculated. Because the procedure is meant to estimate the expected change in individual behavior, it is imperative that the expected results of any program not be presented with a questionable level of precision. The precision with which the expected response of individuals to measurable changes in cost and time, to nonmeasurable changes, and to employer support measures can be estimated is certainly not as clear-cut as estimating the capacity of a new roadway. With this in mind, programs should be developed that yield benefits that outweigh the costs under even the most conservative estimates. In this way, recommendations made about implementing a program can be more easily defended.

## USE OF INCREMENTAL LOGIT MODEL FOR EVALUATING TDM BENEFITS

The incremental multinomial logit formula through which new estimates for the mode choice can be developed, given the implementations of the selected set of TDMs, is presented in this section. To calculate the new choice probabilities for each mode, knowledge of the prior mode choice, the coefficients for each of the independent variables for which a change occurs in the value of the independent variable, and the specific changes in the independent variables is necessary. It is also worth noticing that if a particular mode has a choice probability of zero, then the new estimate also will be zero (*7*).

$$P'_n(i) = \frac{P_n(i)e^{\Delta U_{in}}}{\sum_{j \in C_n} P_n(j)e^{\Delta U_{jn}}}$$

where

- $P'_n(i)$ = choice probability that individual $n$ will select mode $i$, given the implementation of the TDMs;
- $P_n(i)$ = choice probability that individual $n$ will select mode $i$ before implementation of the TDMs;
- $\Delta U_{in}$ = change in utility for alternative $i$ ($= \Sigma\beta_k \Delta X_{ink}$ given that $\Delta X_{ink}$ is change in the $k^{\text{th}}$ independent variable for alternative $i$ and individual $n$ and that $\beta_k$ is the coefficient for the $k^{\text{th}}$ independent variable); and
- $C_n$ = set of modes from which individual $n$ can choose.

## CASE STUDY: SYRACUSE, NEW YORK

### Study Area Description

The purpose of this brief overview is to broadly describe the characteristics of the urban area that must be understood to later focus attention on a single corridor or subarea and its population for which a set of TDMs is to be designed and evaluated.

The study area comprises roughly the area of Onondaga County and includes only small sections of two adjacent counties. The population of the urban study area is about 470,000, of which 163,000 (in 1990) lived within the city of Syracuse. The northern part consists of flat terrain of the Ontario lowlands, and the rest is predominantly hilly terrain in the Allegheny uplands. Most of the major transportation facilities and corridors are concentrated in the flat part of the study area.

The Syracuse area is well served by Interstates I-90 and I-81, which intersect in the city. In addition, two circumferential Interstates (I-690 and I-491) and many state and county highways contribute to providing relatively efficient highway transportation in, through, and around Syracuse. Syracuse also is located on the main rail freight and passenger corridor between Buffalo and Albany (Empire Corridor). Syracuse Hancock International Airport provides service to major metropolitan areas.

The area is served by an areawide public bus system (CENTRO) as well as a shuttle rail service between a major shopping center, a downtown entertainment center, and the campus of Syracuse University. Ridership on CENTRO has steadily decreased over the last 15 years. In fact, in 1990 only 4 percent used mass transit, and 5 percent walked to work. About 40,000 daily work trips are made to the Syracuse central business district (CBD) by all modes of transport, predominantly by automobile, with an additional 16,000 trips by employees of Syracuse University and several medical facilities in the University Hills area. After a decline in the 1980s because of the disappearance of major shopping attractions, the Syracuse downtown area has been revitalized over the past 3 years with upgraded hotels and office buildings adding 2,000 new office jobs.

The major growth areas in Onondaga County lie north and northwest of the city of Syracuse (towns of Clay and Baldwinsville) as well as in the northwestern section of the city, south of Onondaga Lake (Oil City) where a new intermodal transportation center is to connect all local and intercity transportation services. Like other U.S. metropolitan areas, Syracuse has experienced suburban sprawl, with the population and new employment being dispersed. This pattern, together with the substantial highway infrastructure, is conducive to use of the private automobile, and it puts transit service that relies on heavier concentrations of residences and employment sites at a distinct disadvantage.

### Selection and Description of Target Area and Preparation of Input Data for Analysis

The chosen target population and travel corridor should have at least the following characteristics:

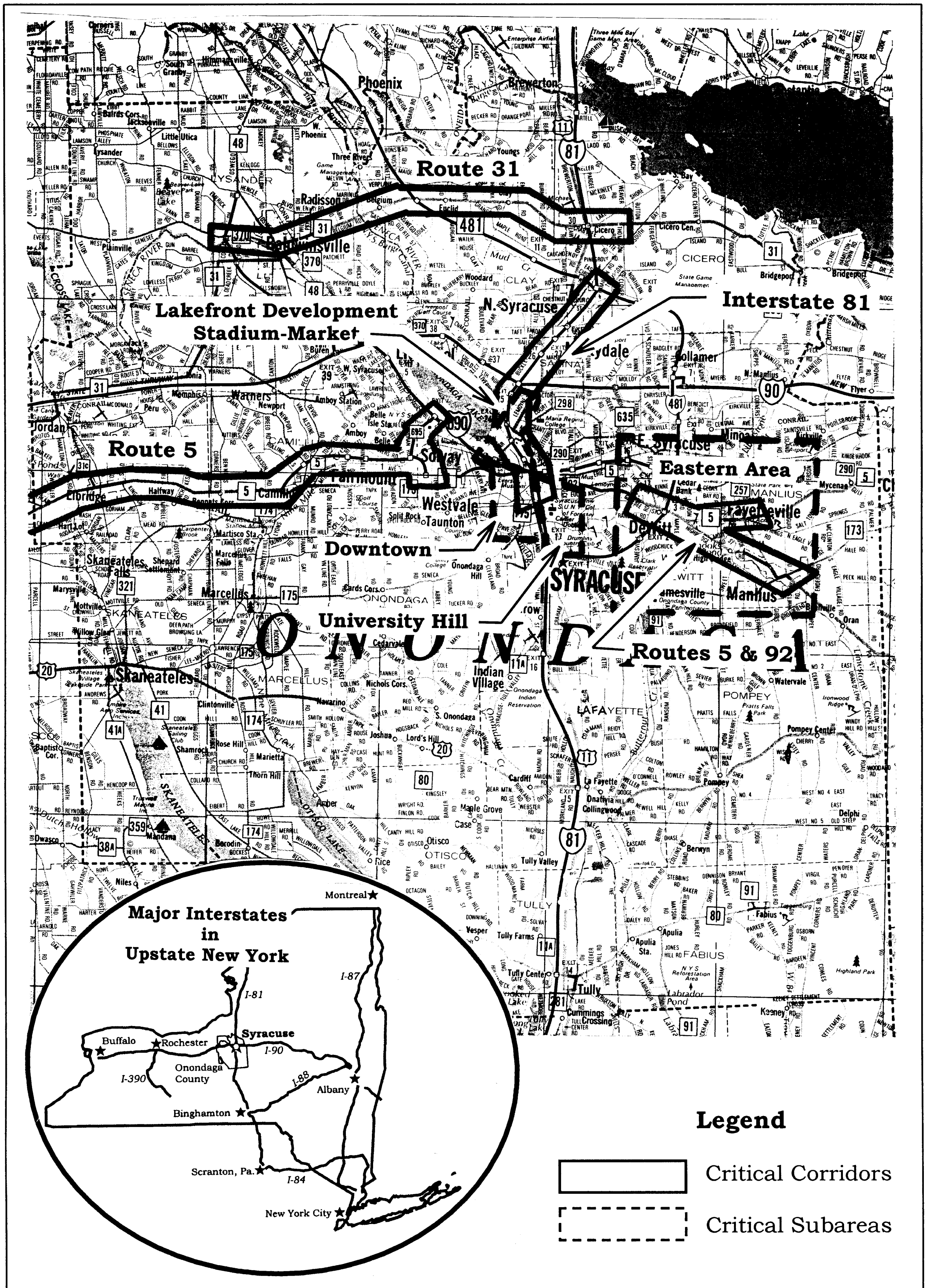
- Some public perception that there is a congestion, parking, or related transportation problem;
- Available alternatives to the drive-alone option or the possibility of providing such alternatives; and
- Large common origin-destination (O-D) pair volumes.

Perception of a transportation problem is required so the public is aware that efforts to change behavior are beneficial and not simply politically motivated.

The critical subareas targeted for further study by the Syracuse Metropolitan Transportation Council (SMTC) were defined as ". . . region[s] that [have], significant mobility concerns such as a high rate of development, traffic demand that exceeds, or will, exceed roadway capacity, and a substandard infrastructure . . ." (*8*). The three identified subareas are the lakefront development district, University Hill, and downtown Syracuse (CBD), as indicated in Figure 1. For this study, the CBD was targeted for the evaluation of TDM measures, because it constitutes the single most important destination in the Syracuse area (*9*).

### Analysis Zone Structure

An important consideration that must be taken into account when utilizing an incremental logit model is that if there is currently a




*Sources: Marshall Penn York Co. Inc. Syracuse, NY*
*2020 Long Range Transportation Plan, SMTC 1990*

**FIGURE 1 Map of study area in Syracuse.**

mode share of zero between a given pair of traffic analysis zones (TAZs), no matter how drastically the characteristics of any mode are changed, that mode's share will always remain at zero. To avoid this problem, the original TAZ structure, with 338 analysis zones, was aggregated to a total of 161 zones (Figure 2). Zones were aggregated to ensure that no zones adjacent to transit lines were joined with zones with no transit service within walking distance. Efforts also were made to ensure that joined zones had nearly the same access to major roadways. For example, if residents of one zone would surely travel I-81 to the CBD, then that zone was not joined to one where the residents would most likely travel I-481. The smaller zones within the borders of the city of Syracuse were left largely unchanged. The CBD, the study area for this analysis, is represented by TAZs 250, 255, and 256.

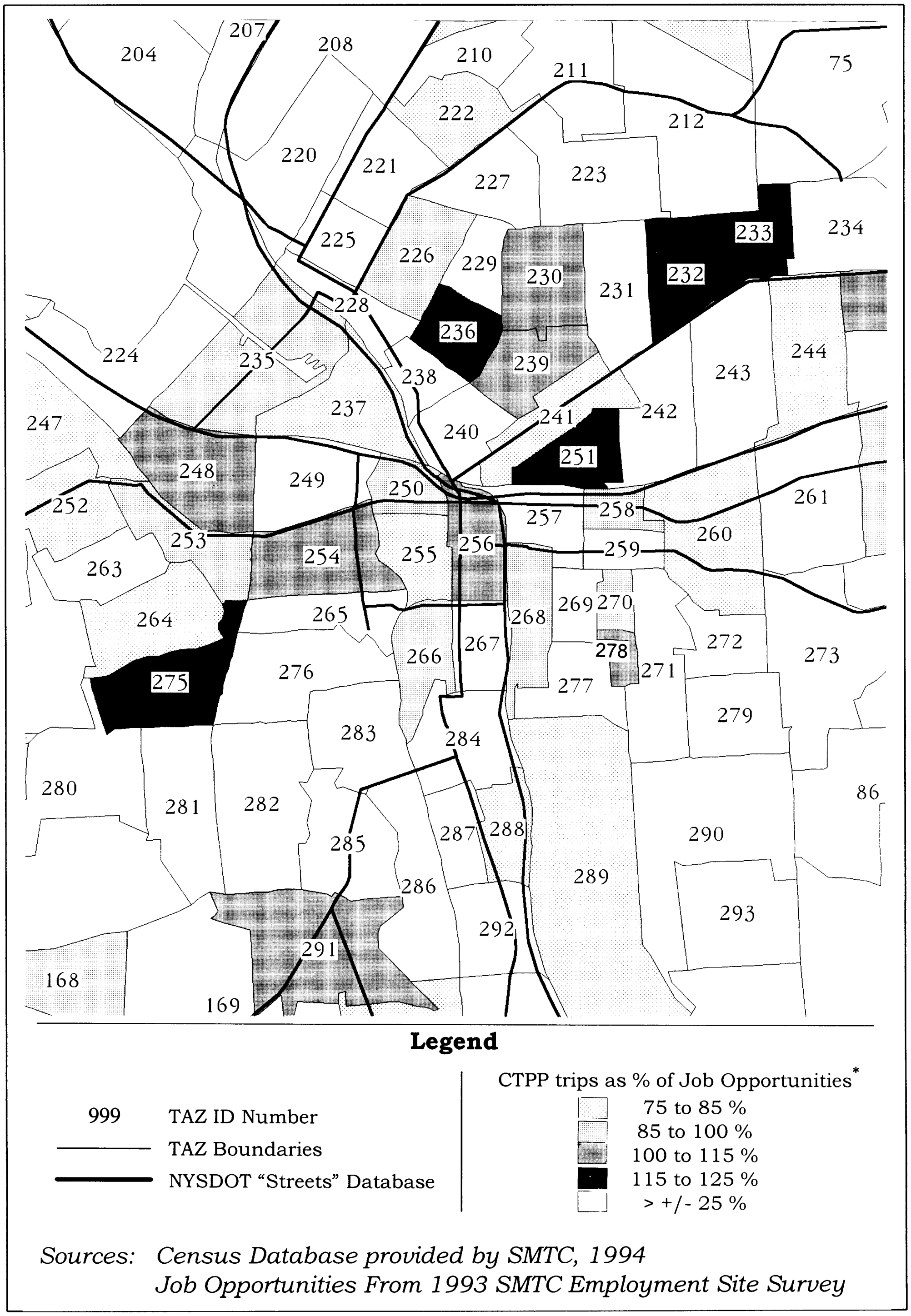



**FIGURE 2 Traffic analysis zones in the study area.**

## Trip Tables

Because home-based work trips (HBW) are concentrated heavily during the peak hour and because it is this large concentration of trips during the peak periods that causes great distress, it is recommended that peak-period HBW trip tables be used in the model. Daily, 24-hour tables may be used, but this will hamper the evaluation of work-hours-shifting strategies. Furthermore, use of such tables will not enable the user to evaluate the effect of the selected strategies on peak-period congestion. Use of these tables would allow the user only to evaluate the change in the expected total number of vehicle trips made daily, the expected new modal split, and the expected reduction of daily VMT. Reliable estimates cannot be made of the effect on recurrent peak-period roadway congestion because there is no accurate way to ascertain the temporal distribution of the adjusted trip tables on the network.

The data available for this study were limited to census journey-to-work information with 24-hour HBW trips. Luckily, however, the temporal distribution of trips arriving at any particular TAZ was available for Syracuse. Hence, peak-period tables were estimated from these temporal arrival patterns by using peak-period multipliers for TAZs 250, 255, and 256 of 0.590, 0.606, and 0.609, respectively.

## Trip Distance and Time

Trip distances for each O-D pair were required if an estimate of the reduction in vehicle miles of travel as a result of any TDM program was expected. Because an entire O-D table for the peak period was not available, it was not possible to load the network and obtain realistic estimates of the travel time between any particular origin and the CBD. Hence, travel distance was estimated as the shortest path along the road network and therefore was based solely on the length of each link in the network. Although the TransCAD geographic information system allows for proper treatment of one-way links, the shortest path provided by it is certainly not the only path taken on a trip between any pair of zones. For example, people often go the long way to avoid certain intersections. Moreover, the distances provided are from the centroid of each TAZ. Not everyone within a TAZ has the same travel distance. Posted speed limits for each link were available. Travel times (minutes) were therefore estimated as the link length divided by the speed limit.

## Summary of Results

### *Cost and Travel Time Changes*

The modes considered in this analysis are automobile, share (two-, three-, four-, and five-person occupancy), and transit. The variables and coefficients for the incremental logit model used in this analysis are as follows:

$$U_k = A_k + 0.02(IVTT) + 0.05(AOVTT) + 0.05(TOVTT) \\ + 0.004(TCOST) + 0.01(PKCOST) + 0.1(HOVTT)$$

where

$U_k$ = disutility of mode $k$;
$A_k$ = mode-specific constant for mode $k$;
$IVTT$ = in-vehicle travel (min);
$AOVTT$ = out-of-vehicle travel time for automobile users (min);
$TOVTT$ = out-of-vehicle travel time for transit users (min);
$TCOST$ = transit fare;
$PKCOST$ = parking cost for automobile users; and
$HOVTT$ = HOV lane travel time savings.

It is important to note that not all terms in the utility equation exist for all modes. The actual coefficients were developed from a study by COMSIS (*10*) through inspection of logit models used by many urban areas throughout the United States. Note that the variables used in the analysis are total in-vehicle travel time, total out-of-vehicle travel time for automobile users, total out-of-vehicle travel time in minutes for transit users, transit cost, parking cost, and HOV-lane travel savings.

The evaluation of all cost- or time-influencing policies is handled by the incremental logit model to estimate resulting travel behavior. The effects of changes in the following cost and travel time variables were investigated:

- Changes to transit fare;
- Changes to transit in-vehicle travel time;
- Changes to transit out-of-vehicle travel time;
- HOV-lane time savings (preferential parking); and
- Changes in parking cost (with individual changes allowed for vehicles with one, two, three, or four or more persons).

Table 1 reveals that significant changes in mode share and in number of vehicle trips made to the CBD are possible through implementation of TDM measures. These significant changes are largely because of sizable increases in parking cost, particularly for SOV travelers. Indeed, relatively large increases in parking cost alone are enough to bring about the desired level of trip reduction, especially when coupled with a refund of the parking surcharge for carpoolers. Of the 25 TDM programs analyzed, 20 required parking cost increases of $1.00 or more. All required that the surcharge be refunded to HOV users.

Two measures were used to adjust the characteristics of the carpool mode. The first was a parking-cost rebate of the new price hike for carpools. In all strategies, vehicles with two or more occupants were given a rebate of $1.00. In 17 of them, vehicles with three or more occupants were given a rebate of twice the parking increase. This rebate could easily be designed as tickets good for one free transit pass to any destination within the county, ensuring a ride home for those not driving. Such tickets also could be used for cash or credit at any downtown establishment. As an added benefit, this practice would enable better monitoring of travel and commerce in the downtown area. Employer subsidies to carpoolers also can be used to offset the inconvenience of carpooling. The second measure to encourage HOV use was travel time savings, such as preferential parking.

There are certainly many possibilities with respect to the proportions of the populations that experience different modal time and cost changes. Nonetheless, the first 25 programs presented in Table 1 indicate the minimum changes in travel time and cost that all employees of downtown must encounter for the program to achieve

**TABLE 1 Areawide Cost and Travel Time Changes**

| Program ID | Parking Cost Increase | 2 Person Parking Rebate | 3+ Person Parking Rebate | Transit Fare Subsidy | Carpool Time Savings (min) | SOV Time Penalty (min) | Transit IVTT Savings (min) | Transit OVTT Savings (min) | % Decrease in Vehicle Trips | % Decrease in VMT | % Decrease in Drive Alone Mode Share | % Increase in Transit Mode Share | % Increase in Carpool Mode Share | Average Vehicle Occupancy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | $ 1.00 | $ 1.00 | $ 2.00 | $ 0.25 | 2.0 | 2.0 | 5.0 | 5.0 | 16.2 | 14.4 | 18.0 | 7.1 | 10.9 | 1.49 |
| 2 | $ 1.00 | $ 1.00 | $ 1.00 | $ 0.25 | 2.0 | 2.0 | 5.0 | 5.0 | 16.1 | 14.2 | 17.9 | 7.1 | 10.8 | 1.49 |
| 3 | $ 1.00 | $ 1.00 | $ 2.00 | $ - | 2.0 | 2.0 | 5.0 | 5.0 | 15.6 | 13.9 | 17.6 | 6.5 | 11.1 | 1.48 |
| 4 | $ 1.00 | $ 1.00 | $ 2.00 | $ 0.25 | 2.0 | 2.0 | 2.5 | 5.0 | 15.6 | 13.9 | 17.6 | 6.5 | 11.1 | 1.48 |
| 5 | $ 1.00 | $ 1.00 | $ 1.00 | $ - | 2.0 | 2.0 | 5.0 | 5.0 | 15.5 | 13.8 | 17.5 | 6.5 | 11.0 | 1.48 |
| 6 | $ 1.00 | $ 1.00 | $ 2.00 | $ 0.25 | 1.0 | 1.0 | 5.0 | 5.0 | 15.0 | 13.2 | 16.4 | 6.9 | 9.5 | 1.47 |
| 7 | $ 1.00 | $ 1.00 | $ 2.00 | $ - | 2.0 | 2.0 | 2.5 | 5.0 | 15.0 | 13.5 | 17.3 | 5.9 | 11.3 | 1.47 |
| 8 | $ 1.00 | $ 1.00 | $ 1.00 | $ 0.25 | 1.0 | 1.0 | 5.0 | 5.0 | 14.9 | 13.1 | 16.3 | 6.9 | 9.4 | 1.47 |
| 9 | $ 1.00 | $ 1.00 | $ 2.00 | $ - | 1.0 | 1.0 | 5.0 | 5.0 | 14.4 | 12.8 | 16.0 | 6.3 | 9.7 | 1.46 |
| 10 | $ 1.00 | $ 1.00 | $ 2.00 | $ 0.25 | 1.0 | 1.0 | 2.5 | 5.0 | 14.4 | 12.8 | 16.0 | 6.3 | 9.7 | 1.46 |
| 11 | $ 1.00 | $ 1.00 | $ 1.00 | $ - | 1.0 | 1.0 | 5.0 | 5.0 | 14.3 | 12.6 | 15.9 | 6.4 | 9.6 | 1.46 |
| 12 | $ 1.00 | $ 1.00 | $ 2.00 | $ 0.25 | 2.0 | 2.0 | 2.5 | 2.5 | 14.2 | 12.8 | 16.8 | 5.2 | 11.6 | 1.46 |
| 13 | $ 1.00 | $ 1.00 | $ 1.00 | $ 0.25 | 2.0 | 2.0 | 2.5 | 2.5 | 14.1 | 12.7 | 16.7 | 5.2 | 11.5 | 1.46 |
| 14 | $ 1.00 | $ 1.00 | $ 2.00 | $ - | 1.0 | 1.0 | 2.5 | 5.0 | 13.9 | 12.3 | 15.7 | 5.8 | 9.9 | 1.45 |
| 15 | $ 1.00 | $ 1.00 | $ 2.00 | $ - | 2.0 | 2.0 | 2.5 | 2.5 | 13.7 | 12.4 | 16.4 | 4.6 | 11.8 | 1.45 |
| 16 | $ 1.00 | $ 1.00 | $ 1.00 | $ - | 2.0 | 2.0 | 2.5 | 2.5 | 13.6 | 12.3 | 16.3 | 4.6 | 11.7 | 1.45 |
| 17 | $ 1.00 | $ 1.00 | $ 2.00 | $ 0.25 | 1.0 | 1.0 | 2.5 | 2.5 | 13.1 | 11.7 | 15.1 | 5.0 | 10.2 | 1.44 |
| 18 | $ 1.00 | $ 1.00 | $ 1.00 | $ 0.25 | 1.0 | 1.0 | 2.5 | 2.5 | 12.9 | 11.6 | 15.0 | 5.0 | 10.0 | 1.44 |
| 19 | $ 1.00 | $ 1.00 | $ 2.00 | $ - | 1.0 | 1.0 | 2.5 | 2.5 | 12.5 | 11.3 | 14.8 | 4.5 | 10.3 | 1.43 |
| 20 | $ 1.00 | $ 1.00 | $ 1.00 | $ - | 1.0 | 1.0 | 2.5 | 2.5 | 12.4 | 11.2 | 14.7 | 4.5 | 10.2 | 1.43 |
| 21 | $ 0.75 | $ 0.75 | $ 1.50 | $ 0.25 | 1.0 | 1.0 | 5.0 | 5.0 | 12.4 | 10.8 | 13.2 | 6.2 | 7.0 | 1.43 |
| 22 | $ 0.75 | $ 0.75 | $ 1.50 | $ - | 1.0 | 1.0 | 5.0 | 5.0 | 11.9 | 10.4 | 12.8 | 5.6 | 7.2 | 1.42 |
| 23 | $ 0.75 | $ 0.75 | $ 1.50 | $ 0.25 | 1.0 | 1.0 | 2.5 | 5.0 | 11.9 | 10.4 | 12.8 | 5.6 | 7.2 | 1.42 |
| 24 | $ 0.75 | $ 0.75 | $ 1.50 | $ - | 1.0 | 1.0 | 2.5 | 5.0 | 11.3 | 9.9 | 12.4 | 5.1 | 7.3 | 1.41 |
| 25 | $ 0.75 | $ 0.75 | $ 1.50 | $ 0.25 | 1.0 | 1.0 | 2.5 | 2.5 | 10.5 | 9.3 | 11.9 | 4.3 | 7.6 | 1.40 |

***Base Case:*** *Person Trips: 33,701; Vehicle Trips: 24,853; Transit Trips: 3676; SOV: 72.1%; Transit: 10.9%; AVR: 1.25* measurable success. Again, it is important to ensure that these minimum measures can be brought to bear on the entire populations or that larger changes can be enforced on some subset of the population in the final recommendations.

In addition, when the recommended TDM program for the target population is defined, care must be taken to ensure that the changes can actually be enforced. Although forethought was used to select "physically" possible programs for the first cut, these measures are not necessarily politically and strategically tenable. In the final program recommendation, adjustments need to be made to the estimated change in travel behavior as a result of implementation constraints.

### *Employer-Based Support Programs*

Employer-based support programs are an important factor in the success of any TDM strategy. Unfortunately, these programs cannot be evaluated by means of the incremental logit model used in this research. Therefore, COMSIS TDM evaluation model factors were used to evaluate these programs. To the authors' knowledge this is the only published application of the COMSIS model. The TDM evaluation model requires that these programs and the intensity with which they are implemented be mapped to support levels. Factors have been developed for five levels. Based on statistical studies undertaken by COMSIS, the program assigns an absolute percentage change in carpool or transit mode share based on the program level (*10*). Shares for the competing modes are then adjusted accordingly.

### *Comprehensive Programs*

The final set of TDM programs is presented in Table 2. These programs are composed of employer initiatives that affect the travel time and costs of employees, TDM support measures, and changes that affect transit service in general (areawide input). These programs assume that the support programs are implemented at work sites in accordance with Table 3. The percentages of employees who participate in alternative work schedules, if available, are as indicated in Table 4. Employer participation rates for cost and time policies are assumed to affect either 55 or 75 percent of employees (i.e., the population relevant to this TDM analysis), as developed in Table 5.

With these employer support measures, in addition to cost and travel time changes, the most promising results of the many model runs performed revealed that even under the most conservative of estimates, a reduction of over 13 percent in the number of vehicle trips to the CBD can be realized (Table 2, lower). When more ambitious programs were studied, under even moderately conservative participation assumptions, this reduction was estimated to be as high as 18 percent (Table 2, upper).

Estimates of the revenue generated by the comprehensive programs presented in Table 2 have also been developed. Again, these revenue estimates were used to arrive at a first cut of comprehensive TDM measures to bring about the goals for the targeted subarea. In particular, the revenue estimates indicated in Table 6 were used to ensure that the selected policy is self-funding.

On the basis of the various analyses performed, the following recommendations are offered concerning measures that are likely to be most effective in achieving work trip reductions in the Syracuse CBD and the associated benefits, as indicated in part in Table 2.

- Increase of $1.00 for CBD parking for SOVs;
- Decrease of $1.00 for two-person carpool in CBD;
- Decrease of $2.00 for three+-person carpool in CBD;
- Decrease of CENTRO fare to $0.75;
- Employer-provided transit subsidy equal to new fare;
- Preferential parking, fee collection, and so forth, for carpools;
- Improved transit accessibility, transit pass programs, and so forth, developed by employers to provide additional transit time savings;
- Systemwide improvements by CENTRO designed to bring about time savings for all routes;
- Work hour shifting strategies made available to 40 percent of downtown employees: 10 percent each flex time, 4 day/40-hour weeks, 9-day/80-hour 2-week periods, and staggered schedules;
- 10 percent of employees made eligible for telecommuting; and
- Establishment of employer support programs for both transit and carpool travelers with program scope dependent on employer size.

Although the effects on localized congestion were not directly estimated, such reductions would lead to greatly improved conditions in downtown Syracuse. Given that there are currently some 25,000 daily private-vehicle work trips to the area, a reduction of as much as 4,500 of those trips would be reason to proceed with the recommended program. The targeted downtown area has 5 of the 10 highest-frequency accident locations and three of the nine worst intersections in the county. This level of private-vehicle trip reductions would relieve those problem areas.

Finally, the projected increase in transit mode share of between 4 and 6 percent translates to an increase in patronage of about 50 percent (Table 2). Without question, such increased patronage will help ensure the continued financial viability of CENTRO and relieve the public of the need for increasing subsidies to CENTRO. Not only should the projected increase in patronage help reverse the worsening financial well-being of CENTRO, it also should lead to improved service. Improved service would increase the attractiveness of the area to visitors and ensure continued mobility for the elderly, the young, the poor, and the disabled. The outrage expressed by the public during hearings on recent transit cutbacks illustrates the need to secure the continued health of transit in the region and the value of such side effects of the recommended programs. Without question, strong transit service is crucial for the continued economic growth of Syracuse.

Of course, if the added ridership exceeds the capacity of the current transit service fleet, additional costs will arise from increasing frequency of service, possible addition of routes, and so forth. These increased costs would have to be subtracted from the revenue column resulting from the implementation of HOV strategies, as described.

### *Model Performance*

Overall, the model performed well enough to accomplish the goal of recommending a set of TDM measures for a given area (Syra-

**TABLE 2 Predicted Effects of Comprehensive TDM Programs for Target Subarea**

| Employer Initiatives Input | | | | | | | Area-Wide Input | | | Expected Results of TDM Program | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SOV Parking Cost Increase | 2 Person Parking Rebate | 3+ Person Parking Rebate | Transit Fare Subsidy | HOV Time Savings (min) | SOV Time Penalty (min) | Transit OVTT Savings (min) | Transit Fare Subsidy | Transit OVTT Savings (min) | Transit IVTT Savings (min) | % Decrease in Person Trips | % Decrease in Vehicle Trips | % Decrease in VMT | % Decrease in Drive Alone Mode Share | % Increase in Transit Mode Share | % Increase in Carpool Mode Share |
| Moderately Conservative Estimates of Expected Employer Participation - 75% of Population Influenced by Employer Incentives | | | | | | | | | | | | | | | |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 0.75 | 2.0 | 2.0 | 2.5 | $ 0.25 | 2.5 | 2.5 | 4.2 | 18.0 | 16.5 | 15.4 | 6.2 | 9.1 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 2.0 | 2.0 | 2.5 | $ - | 2.5 | 2.5 | 4.2 | 17.2 | 15.9 | 14.9 | 5.5 | 9.4 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 0.75 | 1.0 | 1.0 | 2.5 | $ 0.25 | 2.5 | 2.5 | 4.2 | 17.1 | 15.7 | 14.1 | 6.1 | 8.0 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 1.0 | 1.0 | 2.5 | $ - | 2.5 | 2.5 | 4.2 | 16.3 | 15.1 | 13.6 | 5.4 | 8.2 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 2.0 | 2.0 | 0.0 | $ - | 2.5 | 2.5 | 4.2 | 16.2 | 15.2 | 14.2 | 4.5 | 9.7 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 2.0 | 2.0 | 0.0 | $ - | 2.5 | 0.0 | 4.2 | 15.7 | 14.8 | 13.9 | 3.9 | 9.9 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 0.0 | 0.0 | 2.5 | $ - | 2.5 | 2.5 | 4.2 | 15.5 | 14.2 | 12.4 | 5.2 | 7.1 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 1.0 | 1.0 | 0.0 | $ - | 2.5 | 2.5 | 4.2 | 15.4 | 14.3 | 13.0 | 4.4 | 8.6 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 1.0 | 1.0 | 0.0 | $ - | 2.5 | 0.0 | 4.2 | 14.8 | 13.9 | 12.6 | 3.8 | 8.8 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 0.0 | 0.0 | 0.0 | $ - | 2.5 | 2.5 | 4.2 | 14.4 | 13.4 | 11.7 | 4.3 | 7.5 |
| Overly Conservative Estimates of Expected Employer Participation - Only 55% of Population Influenced by Employer Incentives | | | | | | | | | | | | | | | |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 0.75 | 2.0 | 2.0 | 2.5 | $ 0.25 | 2.5 | 2.5 | 4.1 | 16.1 | 14.7 | 13.1 | 5.6 | 7.4 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 2.0 | 2.0 | 2.5 | $ - | 2.5 | 2.5 | 4.1 | 15.3 | 14.1 | 12.5 | 4.8 | 7.7 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 0.75 | 1.0 | 1.0 | 2.5 | $ 0.25 | 2.5 | 2.5 | 4.1 | 15.4 | 14.1 | 12.2 | 5.5 | 6.6 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 1.0 | 1.0 | 2.5 | $ - | 2.5 | 2.5 | 4.1 | 14.6 | 13.5 | 11.6 | 4.8 | 6.8 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 2.0 | 2.0 | 0.0 | $ - | 2.5 | 2.5 | 4.1 | 14.6 | 13.6 | 12.1 | 4.1 | 7.9 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 2.0 | 2.0 | 0.0 | $ - | 2.5 | 0.0 | 4.1 | 14.1 | 13.2 | 11.7 | 3.6 | 8.1 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 0.0 | 0.0 | 2.5 | $ - | 2.5 | 2.5 | 4.1 | 14.0 | 12.9 | 10.7 | 4.6 | 6.0 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 1.0 | 1.0 | 0.0 | $ - | 2.5 | 2.5 | 4.1 | 13.9 | 12.9 | 11.2 | 4.0 | 7.1 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 1.0 | 1.0 | 0.0 | $ - | 2.5 | 0.0 | 4.1 | 13.4 | 12.5 | 10.8 | 3.5 | 7.3 |
| $ 1.00 | $ 1.00 | $ 2.00 | $ 1.00 | 0.0 | 0.0 | 0.0 | $ - | 2.5 | 2.5 | 4.1 | 13.3 | 12.3 | 10.3 | 3.9 | 6.3 |

*Peak-Hour Base Case: Person Trips: 21,086; Vehicle Trips: 16,685; Transit Trips: 2,362; SOV: 70.8%; Transit: 11.2%; AVR: 1.26*
*Each program includes Employer Support as in Table 3 and Work-Hours Shifting Strategies with participation rates as outlined in the text.*

**TABLE 3 Assumed Employer Support Levels for Comprehensive Programs**

| Employee Size Category | % of Employers Implementing Specific Support Levels | | | | |
|---|---|---|---|---|---|
| | No Support | Level 1 | Level 2 | Level 3 | Level 4 |
| 1-49 | 50% | 50% | | | |
| 50-99 | | 50% | 50% | | |
| 100-499 | | | 50% | 50% | |
| 500 and up | | | | 50% | 50% |

cuse) and to establish quantifiable, expected effects for the measures evaluated. Safe estimates of the expected effects of TDM programs were achieved through the use of limited and readily available data.

Key to the success achieved were several surveys and written reports made available by the local metropolitan planning organization (MPO) (SMTC). Such information may not exist or be available for similar efforts elsewhere. The willingness of the SMTC and the Metropolitan Development Association to help with this study was extraordinary. Moreover, a great dependence was placed on Census Transportation Planning Package (UTPP) data that should be available for any urban area soon. For the Syracuse area, the urban part of the UTPP was available. Syracuse was a testing site and, therefore, was one of the first urban area MPOs to secure its UTPP. It provided O-D tables by TAZ for the study area that were instrumental throughout this work. Another very valuable survey made available was the employment site survey conducted by the SMTC. Again, such information may not be available in other urban areas.

Hence, reliance on readily available, secondary data sources for a similar effort in any urban area may not be possible at this time but should be shortly. The quantity and quality of data available are sure to vary considerably from one urban area to another. Nonetheless, this effort did show that estimates of the various TDM programs can be obtained, and the results can be trusted as long as efforts are made to be conscious of the limitations of available data sources.

## CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

The major conclusion reached was that, relying on limited, readily available data and tools only, it is indeed possible to select an appropriate set of TDM measures for a given study area. Conservative estimates of the effectiveness of the selected set of measures were made, with conservative assumptions about employer and employee participation rates (see Tables 2 and 6.) Given the uncertainties of predicting the behavior of travelers to changes in modal characteristics and of predicting the support employers provide to those deciding to use an alternative travel means, it was believed that these conservative estimates were a success. It was also observed that this type of analysis can be effectively integrated into the traditional urban transportation planning process so that effects on congestion can be evaluated. However, further research needs to be done on ways to analyze the incremental benefits of employer support programs.

The ability to evaluate nonmotorized means of transportation within the COMSIS model should be developed. Promotion of such means of transportation and provision of the necessary infrastructure to improve the safety and convenience of such modes are highly recommended with the ISTEA legislation. Moreover, ensuring that walking and bicycling is safe and pleasant would make it easier to leave private vehicles at home. Choosing to carpool or take transit is more attractive if the individual feels free to walk about at both the origin and destination of the journey to work.

**TABLE 4 Assumed Employer Support for Comprehensive Programs**

| Employee Size Category | Assumed % of Area Employees Eligible to Participate | | | | |
|---|---|---|---|---|---|
| | Flex-Time | Staggered Hours | 4 Work Days Each Week | 9 Work Days Every 2 Weeks | Tele-Commuting |
| 1-49 | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% |
| 50-99 | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% |
| 100-499 | 10.0% | 10.0% | 10.0% | 10.0% | 10.0% |
| 500 and up | 10.0% | 10.0% | 10.0% | 10.0% | 10.0% |
| | | | | | |
| Employer Type | Assumed % of Eligible Employees That Participate | | | | |
| | Flex-Time | Staggered Hours | 4 Work Days Each Week | 9 Work Days Every 2 Weeks | Tele-Commuting |
| Office | 22.0% | 22.0% | 22.0% | 11.0% | 19.2% |
| Non-Office | 0.0% | 5.0% | 0.0% | 0.0% | 19.2% |

**TABLE 5 Employer Participation Rates Used in Final Analysis**

| Employer Type | Percentage of Study Area Employment | Employer Participation Rate§ | Percentage of Employees Affected | Employer Participation Rate† | Percentage of Employees Affected |
|---|---|---|---|---|---|
| Office: 1-49 | 23.2 | 25 | 5.8 | 50 | 11.6 |
| Office: 50-99 | 15.5 | 50 | 7.8 | 75 | 11.6 |
| Office: 100-499 | 15.5 | 75 | 11.6 | 90 | 14 |
| Office: 500+ | 23.2 | 75 | 17.4 | 90 | 20.9 |
| Non-Office: 1-49 | 6.8 | 25 | 1.7 | 50 | 3.4 |
| Non-Office: 50-99 | 4.5 | 50 | 2.3 | 75 | 3.4 |
| Non-Office: 100-499 | 4.5 | 75 | 3.4 | 90 | 4.1 |
| Non-Office: 500+ | 6.8 | 75 | 5.1 | 90 | 6.1 |
| Total Percentage of Study Area Employees Affected | | | 55 | | 75 |

§ Considered to be the "overly conservative" point-of-view in Table 2 and in Table 6.

† Considered to be the "moderately conservative" point-of-view in Table 2 and in Table 6.

Use of TDM should become more important in the coming years because of fiscal constraints and worsening congestion. However, nationally the experience and evidence are not promising, given the many political, psychological, and operational constraints on TDM implementation. More research is clearly needed to ensure that proper data are available for evaluation of such strategies. Perhaps there is time before the next decennial census to develop the appropriate questions that must be posed to guarantee that such programs can be evaluated reliably in the future.

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**TABLE 6 Estimated Revenue Generated by Comprehensive TDM Measures**

| Reduction in Daily Peak-Hour Person Trips | Total Daily Person Trips | SOV Person Trips | Transit Person Trips | Carpool Vehicle Trips | Daily Revenue from Parking Hike | Daily Carpool Rebate | Daily Transit Subsidy | Daily Revenue Available for TDM Support Programs and Transit Service Improvements | Annual Revenue Available for TDM Support Programs and Transit Service Improvements |
|---|---|---|---|---|---|---|---|---|---|
| "Moderately Conservative" Expected Employer Participation - 75% of Population Influenced by Employer Incentives | | | | | | | | | |
| 865 | 32836 | 18618 | 5645 | 8570 | $ 18,618 | $ 9,427 | $ 3,528 | $ 5,663 | $ 1,415,765 |
| 865 | 32836 | 18782 | 5415 | 8669 | $ 18,782 | $ 9,536 | $ 4,061 | $ 5,186 | $ 1,296,425 |
| 865 | 32836 | 19045 | 5612 | 8209 | $ 19,045 | $ 9,030 | $ 3,507 | $ 6,508 | $ 1,626,945 |
| 865 | 32836 | 19209 | 5382 | 8275 | $ 19,209 | $ 9,102 | $ 4,036 | $ 6,071 | $ 1,517,661 |
| 865 | 32836 | 19012 | 5086 | 8767 | $ 19,012 | $ 9,644 | $ 3,815 | $ 5,553 | $ 1,388,367 |
| 865 | 32836 | 19111 | 4889 | 8833 | $ 19,111 | $ 9,716 | $ 3,667 | $ 5,728 | $ 1,431,875 |
| 865 | 32836 | 19603 | 5316 | 7914 | $ 19,603 | $ 8,705 | $ 3,987 | $ 6,911 | $ 1,727,814 |
| 865 | 32836 | 19406 | 5054 | 8406 | $ 19,406 | $ 9,247 | $ 3,790 | $ 6,369 | $ 1,592,364 |
| 865 | 32836 | 19538 | 4857 | 8472 | $ 19,538 | $ 9,319 | $ 3,642 | $ 6,576 | $ 1,644,081 |
| 865 | 32836 | 19833 | 5021 | 8045 | $ 19,833 | $ 8,849 | $ 3,766 | $ 7,218 | $ 1,804,569 |
| "Overly Conservative" Expected Employer Participation - 55% of Population Influenced by Employer Incentives | | | | | | | | | |
| 886 | 32815 | 19361 | 5444 | 8007 | $ 19,361 | $ 8,808 | $ 3,403 | $ 7,151 | $ 1,787,721 |
| 886 | 32815 | 19558 | 5182 | 8105 | $ 19,558 | $ 8,916 | $ 3,886 | $ 6,756 | $ 1,688,967 |
| 886 | 32815 | 19656 | 5411 | 7744 | $ 19,656 | $ 8,519 | $ 3,382 | $ 7,756 | $ 1,938,877 |
| 886 | 32815 | 19853 | 5182 | 7810 | $ 19,853 | $ 8,591 | $ 3,886 | $ 7,376 | $ 1,844,020 |
| 886 | 32815 | 19689 | 4952 | 8171 | $ 19,689 | $ 8,988 | $ 3,714 | $ 6,987 | $ 1,746,804 |
| 886 | 32815 | 19820 | 4788 | 8237 | $ 19,820 | $ 9,060 | $ 3,591 | $ 7,169 | $ 1,792,335 |
| 886 | 32815 | 20149 | 5116 | 7548 | $ 20,149 | $ 8,302 | $ 3,837 | $ 8,009 | $ 2,002,354 |
| 886 | 32815 | 19985 | 4919 | 7909 | $ 19,985 | $ 8,699 | $ 3,689 | $ 7,596 | $ 1,898,985 |
| 886 | 32815 | 20116 | 4755 | 7974 | $ 20,116 | $ 8,772 | $ 3,566 | $ 7,778 | $ 1,944,517 |
| 886 | 32815 | 20280 | 4886 | 7646 | $ 20,280 | $ 8,411 | $ 3,665 | $ 8,205 | $ 2,051,167 |

*Mode shares from study of peak hour tables used to estimate full day modal trip distribution. $1 Carpool rebate. 15% of carpools with 3+ Persons and receiving $2 discount. SOVs pay $1 surcharge. Annual revenue based on 50 weeks of five days.*

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